ASPECTS OF NESTING BIOLOGY OF *CROCODYLUS POROSUS* AT BHITARKANIKA, ORISSA, EASTERN INDIA[1]

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The nesting biology of Saltwater Crocodiles *Crocodylus porosus* was studied at the Bhitarkanika mangroves, in Orissa, for two consecutive seasons between March 2005 and September 2006. A total of 54 mound nests were surveyed and monitored during this period. In Bhitarkanika *C. porosus* nest between April and August, during the wet season. The mean dimensions of all the successful nests were: height 55.4 ±5.4 cm, longest axis of base 182 ±12.2 cm. Preferred nest materials included *Achrostichum aureum* and *Phoenix paludosa* along with mud. Of the total number of 54 nests located and monitored, 72.2% had wallows. The number of body pits increased with increasing distance from water ($p < 0.05$). Of the complete clutches examined, the mean clutch size was 43.2 ±22.1 and the mean egg dimensions were: egg length 71.95 ±5.5 mm; egg width 49.3 ±3.9 mm; egg weight 121.5 ±14.0 gm. Six false nests were found among the total of 54 nests (2006), and all were located at distances of < 50 m from the successful nests. Predation was higher for the nests that were built closer to the water source than those built more inland ($p = 0.001$). Predation was relatively higher in the *Achrostichum* patches than in the *Phoenix* patches ($p = 0.001$). The egg collection followed by the Forest Department is discussed and a new strategy is recommended.

Key words: Saltwater Crocodile, *Crocodylus porosus*, nest biology, wallows, Bhitarkanika mangroves

INTRODUCTION

Saltwater Crocodile *Crocodylus porosus* has been recorded from India, Indonesia, Indo-China, Malaysia, Philippines, Papua New Guinea and Australia (Neill 1971; Braizitis 1973). In India, it is distributed sparsely in the Sunderbans (West Bengal), Bhitarkanika (Orissa) and Andaman and Nicobar Islands. Of these areas, Bhitarkanika has the highest density of Saltwater Crocodiles, with more than 1,500 individuals, of which over 10% are breeding individuals (Gopi 2007). Considering the potential vulnerability of the crocodilian species in India, the Government of India enforced protective legislation through the Indian Wildlife (Protection) Act, 1972 to conserve crocodiles and to develop crocodile farming in India. A captive breeding programme for all three species of crocodilians found in India (Mugger Crocodile *Crocodylus palustris*, *C. porosus*, and the Gharial *Gavialis gangeticus*) resulted in the recovery of these species in the wild. The restocking strategy of Saltwater Crocodiles has thus resulted in the successful release of more than 1,500 crocodiles (Kar and Bustard 1989; 1991).

Crocodylus porosus is the only crocodilian that deposits its eggs in a mound nest constructed of vegetation with varying proportions of mud or soil (Kopstein 1929; Deraniyagala 1939; Webb *et al.* 1977; Whitaker and Whitaker 1978; Lang 1980; Magnusson *et al.* 1980; Whitaker *et al.* 1980; Graham 1981). Nesting appears to be mainly during the wet seasons, and total or partial flooding of nests is common: a major cause of embryo mortality is drowning (Webb *et al.* 1977; Magnusson *et al.* 1978, 1980; Magnusson 1982). Studies have been carried out on four nests located in Sri Lanka (Deraniyagala 1939) and four nests were examined in Java (Worrell 1952). Magnusson *et al.* (1978) and Ogilby (1904) gave general descriptions of *C. porosus* nests in Australia. Worrell (1952) gave general descriptions from India and Myanmar. The nesting distribution of *C. porosus* was reviewed throughout its range by Neill (1971).

A detailed review of the available literature confirmed that there are no studies with empirical information on the nesting biology of *C. porosus* in India, though scant records of natural history information have been published as semi-scientific notes and popular articles (Pandav 1998; Gopi 2007). After research and conservation work on this species for over 30 long years, all the information that we have pertains only to the population status and conflict data. The nesting phase is a critical stage in the crocodilian life cycle and difficult to study owing to the harsh terrain and continuous presence of the mother crocodile near the nests. Because of the lack of information on Saltwater Crocodile nesting biology and behaviour, the present study aimed to investigate and collect preliminary information from the Bhitarkanika mangroves. The findings are presented and discussed within the context of

Fig. 1: The Bhitarkanika Wildlife Sanctuary, Orissa, India

the existing information relating to the Bhitarkanika mangroves.

STUDY AREA

This study was carried out in the Bhitarkanika Wildlife Sanctuary (Fig. 1), which is located between 20°30'-20°48' N; 86°45'-87°03' E in the deltaic region of the Brahmani and Baitarani rivers in Kendrapara district of Orissa. The Sanctuary encompasses an area of 675 sq. km of which 115 sq. km is under mangrove cover. The Sanctuary is bounded by the rivers Dhamara to the north, Maipura to the south, Brahmani to the west, and the Bay of Bengal in the east. The 35 km coastline from the mouth of River Maipura up to Barunei forms the eastern boundary of the Sanctuary. The annual rainfall ranges from 920 to 3,000 mm (Fig. 2). Bhitarkanika represents one of the richest and most diversified mangrove flora in the country. Fifty eight species of mangroves have so far been recorded in India, of which 55 are found in Bhitarkanika (Bannerjee and Rao 1990). The existence of one species each of *Rhizophora*, *Heritiera* and *Avicennia*, and four species of *Brnguiera* is one of the interesting features of the flora of Bhitarkanika. The dominant genera of mangroves and their associates include *Acanthus*, *Achrostichum*, *Aegialitis*, *Aglaia*, *Avicennia*, *Excoecaria*, *Brownlowia*, *Brugniera*, *Ceriops*, *Rhizophora*, *Heritiera*,

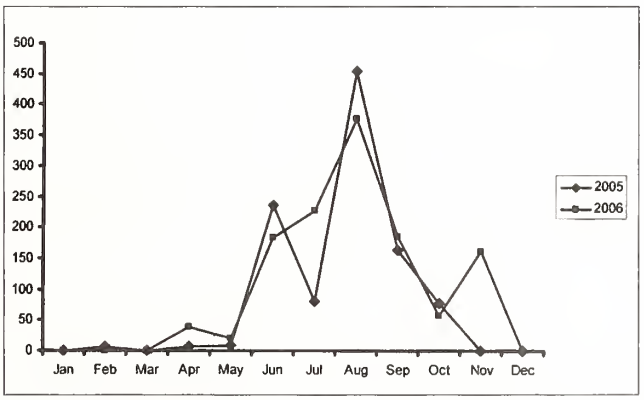

Fig. 2: Monthly rainfall pattern at Bhitarkanika National Park

Hibiscus, *Kandelia*, *Lumnizera*, *Phoenix*, *Sonneratia* and *Suaeda*.

Significant aspects of the fauna of Bhitarkanika mangroves include the presence of India's largest and oldest known heronry (Gopi *et al.* 2007) and the occurrence of the Water Monitor Lizard *Varanus salvator*, King Cobra *Ophiophagus hannah*, Fishing Cat *Prionailurus viverrinus*, Striped Hyaena *Hyaena hyaena*, Sambar *Cervus unicolor* among others. The eastern boundary of Bhitarkanika supports the largest nesting ground in the world of the endangered Olive Ridley Sea Turtle *Lepidochelys olivacea* (Bustard 1976). Gopi and Pandav (2007) report the existence of 263 species of birds in Bhitarkanika of which 87 species have been recorded to breed here.

METHODS

Nests were located by walking along the river/creek banks. Most nests were found by searching areas known to have previously contained a nest. The extent to which the located nests reflect the total number of nests is not known. Upon location of the nests, the size of the nesting crocodile, distance from the nearest water source and number of wallows (body pits) made were recorded. Once the nesting crocodile abandoned the nest after successful rearing of the hatchlings, nest site characteristics were also recorded, which included broad identification of the vegetation patch and canopy cover above the nest site. Nesting adults were not caught and sexed because it was likely that they would abandon the nest. Tracks of only one size were present at each nest site, and it was presumed that this indicates the same individual in attendance. These tracks, combined with sightings, indicated crocodiles between 1.8 and 3.6 m in length, which is consistent with the size of adult females of *C. porosus*. Large tracks, presumably of adult males, were present along the river banks, but not at the nest sites. Disturbance scores of 0-3 were also assigned (Human activities > 91.44 m away from the nest were ranked as 0; human activities > 60.96 m away from the nest were ranked as 1; human activities > 30.48 m away from the nest were ranked as 2 and Human activities > 15.24 m away from the nest were ranked as 3). Nest monitoring was carried out every seven days till the nesting crocodile abandoned the nest site. Notes were also made on predator damage and flooding. Of the 54 located nests, only 39 nests were chosen for regular monitoring due to accessibility reasons. The clutch size and egg dimension data were collected only from those nests that were collected for a forest department managed hatchery. A total of four nests were collected in two years, two each in 2005 and 2006.

RESULTS AND DISCUSSION

Nesting period

Crocodylus porosus nests were constructed starting from the dry season through the wet season with the earliest on around April 20, 2005 and the latest on July 6, 2006 (Fig. 3). *C. porosus* nesting coincided with the annual wet season in Australia and west Java (Worrell 1952; Kopstein 1929; Neill 1971). In Sri Lanka, *C. porosus* nests during the hottest and driest period of the year (July/August), with hatching commencing at the start of the wet season (Deraniyagala 1939). But in Australia, where *C. porosus* starts building the nests in the wet season, this is markedly different (Webb *et al.* 1977). In Bhitarkanika, nesting commenced during the hottest and driest period of the year (April-July).

Nest dimensions and materials

The mean dimensions of the successful nests were: height 55.4 ±5.4 cm (n= 39, range 34 to 82), longest axis of base 182 ±12.2 cm (n=39, range 136 to 261). *Achrostichum aureum* and *Phoenix paludosa* leaves, both dead and fresh green ones accounted for the bulk of the nest materials. *Achrostichum aureum,* also called 'Mangrove Fern', grows in huge clumps, up to 2 m tall. The leaves are large (up to 2 m long), pinnate and bright red when young; fertile leaflets at the tip are covered with red-brown sporangia, and blades of sterile leaflets have a broadly rounded end terminated with a short tip. *Phoenix paludosa,* also known as 'Mangrove Date Palm', is a thorny unbranched, perennial palm, grows up to a height of 5 m or more with top foliages and sharp spines in the stem and leaf apices. The stems are used extensively in the construction of small huts as roof rafters and the framework of the wall. Worell (1952) and Ogilby (1904) described *C. porosus* nesting materials in Australia as "leaf mould" and "grape-vines grasses and other rubbish", respectively. Rushes, reeds and dead leaves are nest constituents in India and Myanmar (Worell 1952).

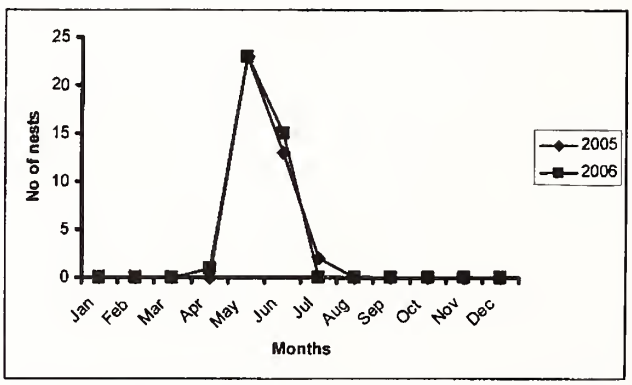

Fig. 3: Monthly breakdown of the new nests found for two consecutive years

Dead materials are used along with tall green grass or herbaceous aquatic plants, most commonly in the Philippines, Indonesia and Papua New Guinea (Neill 1971). In Java, the nests were constructed among 'man height' grass and small branches (Kopstein 1929). In Sri Lanka, there was an association between *C. porosus* and the plant *Lagenandra toxicaria*; *C. porosus* built their nests from it, and the eradication of the plant was closely followed by the disappearance of *C. porosus* from a particular region (Deraniyagala 1939). In Australia, *Ischaemum australe* var. *villosum* appears to replace *L. toxicaria* (Webb *et al.* 1977). Nests of *C. porosus* were similar in form and dimensions in all parts of its range (Neill 1971; Kopstein 1929; Deraniyagala 1939; Webb *et al* 1977).

Body pits/ Wallows

Crocodylus porosus builds body pits close to the nests and stays there till the end of the nesting season. Of the total of 54 nests located, 72.2% had wallows (mean = 1.1). The number of body pits varied between 1 and 4. Pearson correlation was performed to determine whether there is a change in number of body pits with distance from water source. The number of body pits increased with increase in the distance from water $p < 0.05$ (Fig. 4). Wallows beside nests were not mentioned in the study that was carried out in west Java (Kopstein 1929). In Sri Lanka, they are similar to those in northern Australia; some are shallow and seem to result from scraping material for nest construction, while others are deep and used as 'guard wallows' (Deraniyagala 1939). Wallows were found beside nests next to a permanent water source and nests at great distance from such a source (Webb *et al.* 1977).

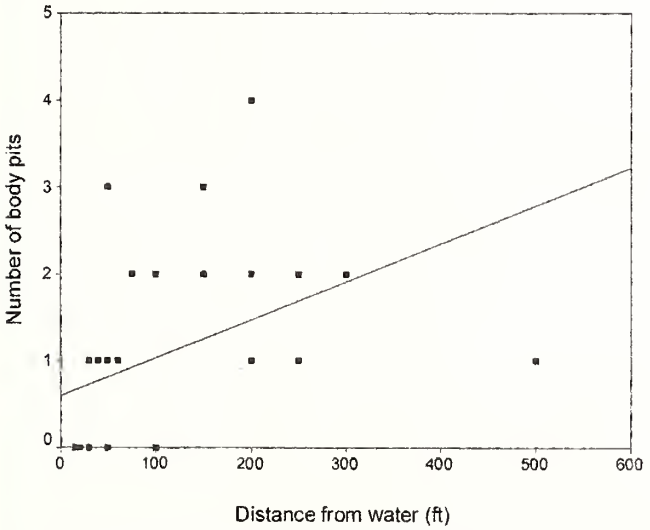

Fig. 4: Relationship between distance from water source and number of body pits made by nesting Crocodiles

Clutch size and egg morphometry

Of the complete clutches examined, the mean clutch size was 43.2 ±22.1 eggs (range 21-72), and the mean egg dimensions of clutch means were: egg length 71.95 ±5.5 mm (n = 70; range 64.2-86.5 mm); egg width 49.3 ±3.9 mm (n = 70; range 41.3-54.6 mm); egg weight, 121.5 ±14.0 gm (n= 70; range 68-138.72 gm). A total of six false nests were located and all the false nests were located at a distance less than 50 m from the completed nests with eggs. Our data on egg numbers and sizes are consistent with other studies conducted elsewhere (Kopstein 1929; Deraniyagala 1939; Webb *et al.* 1977; Worrell 1952). The between-nests variation was much greater than within-nest variation (Kopstein 1929). Egg size (length and width) between-nest variation were greater than within-nest variations ($p = 0.004$).

False Nests

False nests had the same structural composition as that of the completed nests with eggs. False nests were made by small sized crocodiles (1.8-2.4 m). The building of nests without eggs is not clearly understood. This behaviour has been observed in northern Australia (Webb *et al.* 1977). These nests are complete and in all respects resemble nests with eggs, suggesting they may be false nests. The most likely explanations are the following: (1) They are made by immature/ young females. (2) They have been disturbed by humans or other disturbances. (3) The site is not suitable, or change in weather has caused the site to be abandoned.

Predation and flooding of nests

Bhitarkanika and Ragadapatia forest blocks had higher disturbance in terms of human activities that include illegal fishing, honey collection and fuel wood collection. Dangamal forest block was the least disturbed zone due to the presence of the forest department office near the nesting areas (Fig. 5). Pearson chi-square tests showed significantly higher predation ($p < 0.01$) in higher disturbance areas.

Predation was independent of tree and shrub abundance across the nests ($p = 0.400$); however, predation was relatively higher in the *Achrostichum* patches than in the *Phoenix* patches ($p = 0.001$), which was evident while making comparisons with the forest block on predation. Bhitarkanika and Ragadapatia forest blocks accounted for higher predation due to nest building in the *Achrosticlium* patches compared with Dangamal Forest Block where nests were built in *Phoenix* bushes. As *Achrosticlium* patches are softer it is easier for predators to gain access to the nests in them, but in *Phoenix* patches access is relatively difficult for predators due to the spine and thorns associated with this patch. Predation was higher for the nests that were built closer to the water source

than for the nests that were built more inland (p = 0.001). Mother crocodiles that build nests closer to the water keep entering the water source (creek, nalla/river) upon even a slight disturbance, and they construct fewer wallows; however, nest surveillance was higher for the crocodiles that built the nests well inland and thereby prevented predation.

Observations on predated crocodile nests showed signs of two major predators in Bhitarkanika namely Wild Boar (*Sus scrofa*) and Water Monitor Lizards (*Varanus salvator*). Predation on *C. porosus* eggs was minimal in northern Australia (Webb *et al.* 1977). Varanid lizards were found to be the major predators of *C. niloticus* eggs (Cott 1961; Pooley 1969).

The effect of flooding on *C. porosus* nests in northern Australia is catastrophic (Webb *et al.* 1977). Flooded nests were also found in Java (Kopstein 1929), whereas in Sri Lanka flooding of nests posed very little danger to the nests (Deraniyagala 1939). In Bhitarkanika, earlier nesting removes the danger of flooding of nests.

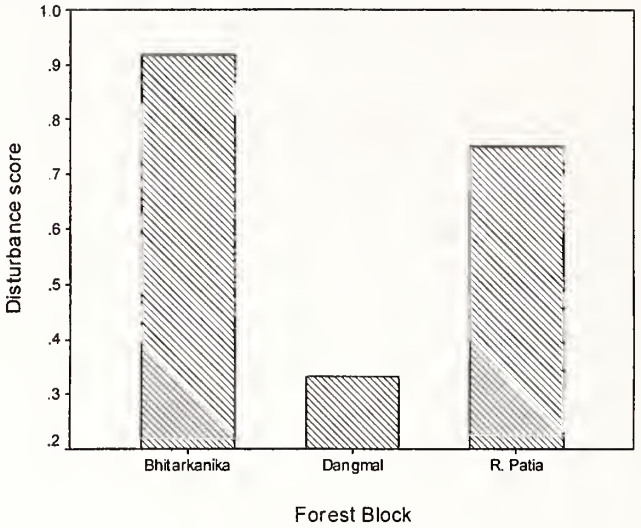

Fig. 5: Relationship between disturbance score and forest block

CONCLUSION

Currently the Orissa Forest Department still manages the crocodile hatchery in Dangamal forest block. During the last two decades more than 5,000 eggs were collected from the forest blocks of the Sanctuary of which 2,695 hatchlings hatched (51%) and 2,488 crocodiles survived (92%). These eggs have been collected from wild nests randomly over the years. Currently two to four wild nests are excavated annually and brought to the hatchery for its rear and release programme. This study clearly shows predation to be higher in the softer *Acrostichum* patches and in the nests that are built very close to a water source (rivers, creeks and nallas). Efforts should be made to carry out further collections in coming years from these nests which have lower survival expectancy than in nests collected randomly. Empirical studies pertaining to hatchling and juvenile recruitment, and survival rates and behavioural ecology could be carried out in future in the Bhitarkanika mangroves, considering the existing gap in the knowledge of Saltwater Crocodiles. With the prospect of increasing man-animal conflicts in Bhitarkanika, the information obtained will pave way for a robust scientific carrying capacity assessment for Saltwater Crocodiles in Bhitarkanika in the days to come.

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